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1 METHOD AND SYSTEM FOR COMMUNICATING
2 INFORMATION WITHIN A PHYSICAL LINK LAYER

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4 This invention relates to the field of packet based
5 communications systems. More particularly, this
6 invention relates to a method and apparatus that permits
7 direct communication of information between elements
8 within the physical link layer of a packet based
9 communication system.

10

11 Background Art

12

13 A schematic representation of an Open Systems
14 Interconnection (OSI) model 1 is presented in Figure 1.
15 The OSI model 1 is a seven layer reference model
16 recommended by the International Standards Organisation
17 (ISO) to provide a logical structure for network
18 operations protocol. Within the OSI model 1 a Physical
19 Link Layer 2 is defined as the lowest layer and above
20 this lies a Datalink Layer 3. The Datalink layer has
21 several functions 3, but within a packet based
22 communication system the Datalink layer 3 performs the
23 task of encoding and decoding a data stream into discrete
24 data packets.

1 The Physical Link Layer 2 is often conveniently
2 subdivided into a Physical Coding Sub-layer (PCS) 4, a
3 Physical Media Attachment (PMA) layer 5 and a Physical
4 Media Device (PMD) layer 6. The PCS 4, further encodes
5 the packet data suitable for transmission across the
6 physical media. The PMA 5 provides an attachment layer
7 between PCS 4 and the PMD 6. The PMD 6 is responsible
8 for the physical transmission of the signal.

9

10 Figure 2 presents a schematic representation of a packet
11 based communication system 7, as is known to those
12 skilled in the art e.g. an Ethernet or a Fibre Channel
13 systems. The packet based communication system 7 is
14 shown in a simplified form so as to comprise a
15 transmitter 8 that performs the tasks of the PMD layer 6
16 and optionally also the PMA layer 5. The transmitter 8
17 acts to convert the packet encoded electrical input
18 signal "in" 9, produced within the higher Datalink layer
19 3 and PCS layer 4, into a data packet signal 10 suitable
20 for transmission through a propagation medium 11. In
21 this example the data packets 10 comprise optical signals
22 for transmission through an optical fibre. At the output
23 of the propagation medium 11 is located a receiver 12.
24 The receiver 12 is employed to detect the signals in a
25 PMD layer 6 and PMA layer 5 device and convert them into
26 an electrical output signal "out" 13 for packet de-coding
27 within the PCS layer 4 and Datalink layer 3 of the packet
28 based communication system 7.

29

30 Further detail of the transmission of a data stream,
31 comprising a plurality of data packets 10, within the
32 propagation medium 11 is shown in Figure 3. These
33 schemes are employed by IEEE 802.3 Ethernet, ANSI Fibre
34 Channel, OIF SPI and SFI Physical Link Layer Standards.

1. It is known to those skilled in the art that the data
2 packets 10 are required to be dispersed with idle data
3 fields 14 which are again produced within the Datalink
4 layer 3 of the packet based communication system 7.

5

6 In particular, the data packets 10 are encoded so as to
7 only contain certain data characters, and prohibit
8 others, and are further delimited by special formatting
9 characters that act to frame the data packets 10. The
10 idle data field 14 contains other special and unique data
11 characters that make them very distinct from the data
12 packets 10. For example, in the Ethernet standard 802.3
13 Clause 36, the idle data fields 14 comprise the comma
14 character, alternatively called a K28.5 pattern, that has
15 one unique 10-bit word pattern 1100000101. During the
16 idle period no data is conveyed from the transmitter 8 to
17 the receiver 12, the idle data fields 14 being required
18 only to retain the link "up" status between the
19 transmitter 8 and the receiver 12 so as to retain data
20 clock synchronisation at the receiver 12.

21

22 Within the aforementioned packet based communications
23 systems there is no facility, post packet encoding, for
24 inserting or extracting information at the Physical Link
25 Layer 2, within the PMA layer 5 or the PCS layer 4.
26 Thus, once the electrical input signals "in" 9 have been
27 encoded as packets within the standard Datalink layer 3
28 or the PCS layer 4 there is no means within the prior art
29 systems for exploiting the substantially unused idle data
30 fields 14.

31

32 It is an object of an aspect of the present invention to
33 provide a method and apparatus that permits direct
34 communication of information between elements within the

1 physical link layer of a packet based communication
2 system.

3

4 According to a first aspect of the present invention
5 there is provided a method of communicating information
6 within the physical link layer of a packet based
7 communication system that comprises the steps of:

8 1) Employing a physical link layer transmitter to
9 substitute an additional input data field within
10 an idle data field of a data stream transmitted
11 within the packet based communication system ; and

12 2) Employing a physical link layer receiver to
13 extract the additional input data field without
14 corrupting information contained within the data
15 stream.

16

17 Preferably the step of substituting an additional input
18 signal within an idle data field comprises the steps of:

19 1) Detecting one or more idle data field characters;
20 and

21 2) Replacing the one or more idle field data
22 characters with a physical link layer data
23 character.

24

25 Optionally the one or more idle field data characters to
26 be replaced are located within two or more of the idle
27 data fields.

28

29 Preferably the step of extracting the additional input
30 data field without corrupting information contained
31 within the data stream comprises the steps of:

32 1) Detecting one or more physical link layer data
33 characters; and

1 2) Extracting and replacing the one or more physical
2 link layer data characters with idle field
3 characters.

4

5 Preferably the step of replacing the one or more idle
6 field data characters with the physical link layer data
7 characters comprises replacing one or more idle field
8 data characters with a start data insertion multiplexer
9 character.

10

11 Preferably the step of replacing the one or more idle
12 field data characters with the physical link layer data
13 characters further comprises replacing one or more idle
14 field data characters with a data control character.

15

16 Preferably the step of replacing the one or more idle
17 field data characters with the physical link layer data
18 characters comprises replacing one or more idle field
19 data characters with an additional input data character.

20

21 Optionally the step of replacing one or more idle field
22 data characters with the physical link layer data
23 characters further comprises the step of replacing one or
24 more idle field data characters with an end input data
25 character.

26

27 Preferably the step of detecting the physical link layer
28 data comprises activating a data extraction de-
29 multiplexer when the receiver detects one or more start
30 data insertion multiplexer characters.

31

32 According to a second aspect of the present invention
33 there is provided a packet based communication system
34 comprising one or more transmitters, one or more

1 transmission media and one or more receivers wherein at
2 least one of the one or more transmitters comprises a
3 data insertion multiplexer for generating and inserting
4 physical link layer data, and at least one of the one or
5 more receivers comprises a data extraction de-multiplexer
6 for detecting and extracting the physical link layer
7 data.

8

9

10 Brief Description of Drawings

11

12 In the following detailed description of the preferred
13 embodiments or mode, reference is made to the
14 accompanying drawings, which form part hereof, and in
15 which are shown, by way of illustration, specific
16 embodiments in which the invention may be practised. It
17 is to be understood that other embodiments may be
18 utilised and structural changes may be made without
19 departing from the scope of the present invention.

20

21 FIGURE 1 shows a schematic representation of a prior art
22 Open Systems Interconnection (OSI) model;

23

24 FIGURE 2 shows a typical prior art packet based
25 communications system at the physical link
26 layer;

27

28 FIGURE 3 shows a typical data packet transmission within
29 the communications system of Figure 2;

30

31 FIGURE 4 shows a packet based communications system at
32 the physical link layer that employs the method
33 and apparatus for inserting an additional field

1 in accordance with aspects of the present
2 invention;

3

4 FIGURE 5 shows a schematic representation of the
5 additional data field when inserted between two
6 data packets by the packet based communications
7 system of Figure 4;

8

9 FIGURE 6 shows details of a coding field of the
10 additional data field of Figure 5;

11

12 FIGURE 7 shows a flow diagram of the method employed by
13 a data insertion multiplexer of a transmitter
14 of Figure 4, employed to insert the additional
15 data field; and

16

17 FIGURE 8 shows a flow diagram of the method employed by
18 a data extraction de-multiplexer of a receiver
19 of Figure 4, employed to extract the additional
20 data field.

21

22

23 Detailed Description

24

25 A packet based communications system 15 at the physical
26 link layer that employs a method of inserting an
27 additional field in accordance with an aspect of the
28 present invention, is presented in Figure 4. The
29 physical link layers of the packet based communications
30 system 15 can be seen to comprise common elements with
31 the prior art system shown in Figure 2, and described
32 above, therefore for clarity purposes the same reference
33 numerals are employed throughout, as appropriate.

34

1 The packet based communications system 15 can be seen to
2 comprise a transmitter 8, a propagation medium 11 and a
3 receiver 12. The form of the data packets 10 generated
4 by the transmitter 8 are again controlled by an
5 electrical input signal "in" 9 produced within the
6 Datalink layer 3 before reaching the physical link layer
7 of the packet based communication system 15. The
8 receiver 12 again is employed to convert the detected
9 data packets 15 into an electrical output signal "out" 13
10 for use within the datalink layer 3 of the packet based
11 communication system 15.

12

13 The transmitter 8 is partitioned into a data packet
14 encoder source 16, a data insertion multiplexer element
15 (MUX) 17 and an physical output stage 18. The signal
16 transmitted via the propagation medium 11 is received at
17 the receiver 12, which has been partitioned into an
18 physical input stage 19, a data extraction de-multiplexer
19 element (DEMUX) 20 and a data packet decoder 21. An
20 additional input data "datin" 22 field can be inserted
21 within the normal input signal "in" 9 by the MUX 17, as
22 described below. The additional input data 22 can then
23 be extracted by the DEMUX 20, so as to provide a "DatOut"
24 23 signal in addition to the normal output signal "out"
25 13, as described below.

26

27 Figure 5 shows an example additional input data "DatIn"
28 22 field inserted between two data 10 of a transmitted
29 signal. The additional input data "DatIn" 22 field is
30 inserted by employing the MUX 17 to replace a portion of
31 the idle data field 14 by swapping out individual idle
32 field characters 24. In a reciprocal manner the
33 additional output data "DatOut" 23 field is extracted by
34 employing the DEMUX 20 to replace the additional input

1 data "DatIn" 22 field by swapping in individual idle
2 field characters 24.

3

4 Figure 6 shows detail of a coding scheme employed within
5 the additional input data "DatIn" 22 field so as to
6 provide for its insertion and extraction. The coding
7 field can be seen to comprise three distinct sub fields
8 namely, a series Start Of MUX characters (SOM) 25,
9 control characters CNT_A and CNT_B 26 or a plurality of data
10 characters DAT₁ to DAT_n 27.

11

12 Figure 7 presents a flow diagram of the method employed
13 by the MUX 17 of the transmitter 8 when operating to
14 insert the additional input data "DatIn" 22 field. In
15 general the states are advanced and decisions are made on
16 the arrival of each character from the data packet
17 encoder source 16.

18

19 Transmitter START 28, SEND IDLE 29 and SEND SOM 30 stages
20 are included and all correspond to the initial activation
21 of the transmitter 8, as is known to those skilled in the
22 art. In particular, the Transmitter START 28 stage is
23 typically determined by a power on condition, an external
24 reset, or a manual reset override. Following the
25 Transmitter START 28 stage the MUX 17 inserts an initial
26 sequence of idle field characters (not shown) into the
27 data stream being sent to the channel receiver by
28 employing the SEND IDLE 29 stage. The idle field
29 characters are in a sufficient amount to allow data
30 recovery synchronisation in the channel receiver as per
31 an appropriate standard, and typically comprise a
32 programmable quantity. After the initial idle sequence,
33 SOM characters (not shown) are sent by the SEND SOM 30
34 from the MUX 17. These SOM characters (not shown) are

1 employed to clearly indicate that additional input data
2 is to be sent and are required to be easily
3 distinguishable from the idle characters and the start of
4 data packet characters. Again the actual number of SOM
5 characters (not shown) sent is typically a user
6 programmable quantity.

7
8 The next stage involves the transmission of the normal
9 data packets 10 by the MUX 17, as represented by a SEND
10 NORM 31 stage. This continues until such time that START
11 MUX 32 stage sets a YES branch that occurs when the MUX
12 17 continuously detects idle characters 24. The
13 particular number of idle characters required to set the
14 YES branch is user programmable. The START MUX 32
15 branches NO immediately on the next character, if a data
16 packets 10 is detected in the data stream, regardless of
17 whether the full additional input data "DatIn" 22 has
18 been sent so preventing any corruption of the normal data
19 packets 10.

20
21 A SENT SOM ? 33 stage then branches YES only when a
22 suitable, programmable, quantity of SOM characters 25
23 have been sent. If a SENT SOM ? 33 NO condition occurs
24 then an additional SOM character 25 is sent by a SEND SOM
25 34 stage of the MUX 17. Following the SOM character 25
26 being sent the state returns back to START MUX 32 and
27 continues with the insertion of the additional input data
28 "DatIn" 22 only if no non idle characters 24 are present
29 in the data stream from the packet encoder 16.

30
31 Next a SENT CNT ? 35 stage branches YES only when a
32 suitable, programmable, quantity of CNT_i characters 26
33 have been sent. If a SENT CNT ? 35 NO condition occurs
34 then an additional CNT_i character 26 is sent by a SEND CNT

1 36 stage of the MUX 17. Following the CNT_i character 26
2 being sent the state returns back to START MUX 32 and
3 continues with the insertion of the additional input data
4 "DatIn" 22 only if no non idle characters 24 are present
5 in the data stream from the packet encoder 16.

6

7 A SENT DAT ? 37 stage then branches YES only when a
8 suitable, programmable, quantity of DAT characters 27
9 have been sent. If a SENT DAT ? 37 NO condition occurs
10 then an additional DAT character 27 is sent by a SEND DAT
11 38 stage of the MUX. Following a DAT character 27 being
12 sent the state returns back to START MUX 32 and continues
13 with the insertion of the additional input data "DatIn"
14 22 only if no non idle characters 24 are present in the
15 data stream from the packet encoder 16.

16

17 Figure 8 presents a flow diagram of the method employed
18 by the DEMUX 20 of the receiver 12 when operating to
19 extract the additional input data "DatIn" 22 field so as
20 to produce an additional output data "DatOut" 23 field.
21 In general the states are advanced and decisions are made
22 on the arrival of each character from the transmitter 8,
23 via the propagation medium 11 and the input stage 19.

24

25 The Receiver START 39 stage is entered on a power on
26 condition, external reset, manual reset override,
27 whenever there is a loss of data synchronisation, or when
28 no signal is detected due to an interruption of the data
29 link from the input stage, as is typical of those systems
30 known in the prior art. Following the Receiver START 39
31 stage a First DETECT SOM? 40 stage is entered on the
32 arrival of the first character of the data stream. This
33 stage branches YES only if a SOM character (not shown) is
34 detected indicating that a transmitter 8 suitable for

1 generating additional input data "DatIn" 22 fields is
2 present on the physical link layer 15. On a NO branch
3 being outputted no additional input data "DatIn" 22
4 characters are assumed to be capable of being
5 transmitted, therefore a first SEND NORM 41 stage of the
6 DEMUX 20 acts so as to pass data packets 10 through to
7 the packet decoder 21 from the input stage 19.

8
9 However, when a YES branch is outputted by the First
10 DETECT SOM ? 40 Stage a First INSERT IDLE 42 stage then
11 strips the SOM character (not shown) and replaces it with
12 an Idle character 24 that is then sent by the DEMUX 20
13 onto the packet decoder 21.

14
15 A Second DETECT SOM ? 43 stage is then employed to detect
16 the presence of subsequent SOM characters (not shown).
17 On a YES branch being outputted from the Second DETECT
18 SOM ? 43 stage a Second INSERT IDLE 44 stage then strips
19 the SOM character 25 and replaces it with an Idle
20 character 24 that is then sent by the DEMUX 20 to the
21 data packet decoder 21. The DEMUX 20 state then returns
22 to the Second DETECT SOM ? 43 stage. Thus, the SOM
23 characters (not shown) are prevented from entering the
24 data packet decoder 21, so as to avoid a potentially
25 erroneous operation within it.

26
27 On a NO branch being outputted from the Second DETECT SOM
28 ? 43 stage a Second SEND NORM 45 stage of the DEMUX 20
29 acts to pass the data packets 10 to the packet decoder 21
30 in the normal manner. The DEMUX 20 then progresses to a
31 DETECT MUX ? 46 stage that monitors the data stream
32 searching for the presence of the additional input data
33 "DatIn" 22 field. When no additional input data "DataIn"

1 22 field is detected the DEMUX 20 returns to the Second
2 SEND NORM 45 stage.

3

4 However, when the DETECT MUX ? 46 stage branches YES the
5 DEMUX 20 moves to a Third INSERT IDLE 47 stage that acts
6 to extract a character from the additional input data
7 "DatIn" 22 field send it on as required within the
8 additional output data "DatOut" 23 field.
9 Simultaneously, the Third INSERT IDLE 47 stage replaces
10 the extracted character with an idle character 24 that is
11 sent on to the packet decoder 21. The DEMUX 20 then
12 returns to the DETECT MUX ? 46 stage and repeats the
13 above process so as to sequentially remove and replace
14 all of the SOM 25, Control 26 and Data 27 characters of
15 the additional input data "DatIn" 22 field. Once
16 completed the DETECT MUX ? 46 stage branches NO and so
17 the DEMUX 20 returns to the Second SEND NORM Stage 45.

18

19 The above description describes a method wherein the
20 complete additional input data "DatIn" 22 field is
21 inserted within an idle data field 14 at the physical
22 link layer of a packet based communications systems 15.
23 If the idle data field is not large enough to contain the
24 full additional input data "DatIn" 22 field then the
25 insertion process is stopped and commences again from the
26 start when the next available idle data field 24 is
27 detected. It will be apparent to those skilled in the
28 art that the method may easily modified so that separate
29 parts of the additional input data "DatIn" 22 field may
30 be transmitted within different idle data fields 24.
31 This could be achieved by the insertion of one or more
32 END characters within the additional input data "DatIn"
33 22 field so that the receiver knows when a full
34 additional input data "DatIn" 22 field has been

1 transmitted. Alternatively, this could also be achieved
2 by the use of additional special character codes that
3 specifically mark the additional input data 22 as an
4 incomplete field.

5

6 Further alternative embodiments that will be apparent to
7 those skilled in the art include extending the described
8 system to comprise more than one channel, two-way
9 channels or multi-channel systems with additional input
10 data "DatIn" 22 fields being exchanged between these
11 channels.

12

13 The described method may also be readily incorporated
14 within a number of transmission media including, but not
15 limited to, over air, optical fibre, printed circuit
16 board or cable. Similarly different types of
17 transmission signal formats may be employed including,
18 but not limited to, analogue, digital, modulated, un-
19 modulated, return to zero coding, non return to zero
20 coding, encoded data, non encoded data, multi-level,
21 binary, continuous or discontinuous, framed, burst or
22 packet based or any combination of these.

23

24 Different types of transmission techniques may also be
25 employed including, but not limited to, electrical,
26 electro-magnetic, magnetic or optical means.

27

28 The described method relates to a communication system
29 where only one transmitter and one receiver is used with
30 one media channel. However, in alternative embodiments,
31 transmission can be made from more than one transmitter
32 sharing one or more media channels to one or more
33 receivers. Furthermore the transmitter and the receiver
34 are described as being two separate elements or

1 components of the system. However, in alternative
2 embodiments, the transmitter and the receiver can be
3 joined or part joined within the same combined element or
4 component of the system, as relevant to multi-channel bi-
5 directional applications. In yet further alternative
6 embodiments the transmitter and/or the receiver can
7 comprise a different combination of separate elements in
8 a combination with less or additional elements so as
9 could be viewed to act as a transmitter and or receiver,
10 respectfully.

11

12 Further alternative embodiments to the communication
13 system include the system comprising:

- 14 • additional filters, transducers, amplifiers,
15 sensors or other elements or components between
16 the transmitter and receiver.
- 17 • separate sections of media, separated by filters,
18 transducers, sensors, transponders, transceivers,
19 transmitters, receivers or other elements so as
20 the break the media into one or more sections of
21 not necessarily the same type of media.

22

23 Alternative embodiments for the transmission of data
24 within the physical layer include no idle characters
25 being employed either side of the additional input data
26 "DatIn" fields. Other coding schemes and data structures
27 can also be readily incorporated within the additional
28 input data "DatIn" fields. In particular the CNT data
29 can contain a unique physical port address identifying
30 that physical device on the link layer. This can be
31 used, for example, in links where a device is employed as
32 a physical layer repeater. Each device can then be pre-
33 assigned or dynamically assigned the unique identifier as
34 appropriate.

1
2 In a further embodiment of the above method it may be
3 desirable not to extract the additional output data
4 "DatOut" fields at the DEMUX but instead to employ this
5 element to pass on or alternatively add additional data.
6 This would be the case, for example, where the device is
7 employed as a physical link layer repeater. This would
8 allow for physical link information to permeate through
9 the system to the channel final receiver. In this way
10 the final receiver can gather all the additional input
11 data "DatIn" fields on the link whilst each repeater in
12 the link can also receiving its necessary physical link
13 data. Such features can be added by having a suitable
14 pass/block flag set in the control character CNT of the
15 additional data field.
16
17 In a bi-directional or multi-directional communications
18 system embodiment the control character field CNT, or
19 elsewhere within the additional mux data field, may
20 contain link status flags. These flags can be used to
21 arrange a handshaking protocol for establishing link-up
22 status between all sets of transmitters and receivers
23 before any data is transferred and providing
24 acknowledgement of successful data transfer in
25 conjunction with a suitable error detection scheme in the
26 data such as cyclical redundancy checking (CRC).
27
28 The above method provides a means for improving the
29 efficiency of a packet based communications systems by
30 exploiting existing relevant standards to transmit a
31 quantity of additional data by encoding it within one of
32 the existing fields of the defined packet structure.
33 Such additional data can be used for any purpose as
34 desired, but in the described embodiment the additional

1 data is required specifically for the physical link. The
2 information includes transmitter and receiver physical
3 parametrics and such information is employed in addition
4 to any existing data provisioned within any known
5 standard.

6

7 The additional information is conveniently multiplexed
8 within the physical link layer whilst being transparent
9 to the normal packet based data. Employing this method
10 puts no extra bandwidth requirement on the communications
11 system. A significant benefit of multiplexing this data
12 at the physical link layer itself is that it allows data
13 to be added, extracted and stripped within the physical
14 layer device at the point where the information is both
15 available and required. This is architecturally
16 efficient and leads to a performance, cost and size
17 superior solution when compared to other conceivable
18 alternatives.

19

20 The foregoing description of the invention has been
21 presented for purposes of illustration and description
22 and is not intended to be exhaustive or to limit the
23 invention to the precise form disclosed. The described
24 embodiments were chosen and described in order to best
25 explain the principles of the invention and its practical
26 application to thereby enable others skilled in the art
27 to best utilise the invention in various embodiments and
28 with various modifications as are suited to the
29 particular use contemplated. Therefore, further
30 modifications or improvements may be incorporated without
31 departing from the scope of the invention herein
32 intended.